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(71) Applicant: AT&T Corp.
New York, NY 10013-2412 (US)

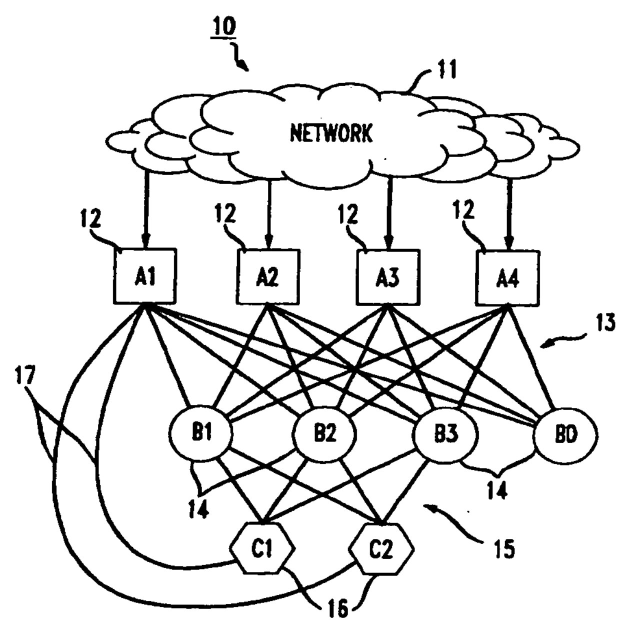
(72) Inventors:
- Diaz, Alvaro H.
Holmdel, N.J. 07733 (US)
- Milito, Rodolfo Alberto
Piscataway, N.J. 08854 (US)

(74) Representative:
KUHNEN, WACKER & PARTNER
Alois-Steinecker-Strasse 22
85354 Freising (DE)

(54) System and method for intergrated overload control and message Distribution

(57) A message distribution system having multiple message processors provides integrated overload control and message distribution. An additional "dummy" message processor is established by the system, to which a certain fraction of messages is assigned as though it were a real processor, thereby accomplishing rejection of that fraction of messages. The fraction to be rejected is determined in real time based on the states of the various processors, which also is the basis for the allocation among the processors of those messages that are not rejected.

FIG. 1



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Summary of the Invention

It is an object of this invention to provide a method for integrating overload control -- i.e., the rejection of messages by the system -- with the distribution of messages among message processors, as well as to provide a system utilizing such a method.

It is a further object of this invention to provide such a method that operates in a simple and efficient manner, as well as a system utilizing such a method.

In accordance with this invention, there is provided a method for distributing messages among message processors in a system having a plurality of message processors and at least one distribution node for receiving messages and distributing the messages to the message processors, wherein different ones of the messages occupy respective ones of the message processors for different durations. The method comprises providing a virtual message processor in addition to the plurality of message processors, whereby messages arriving at the virtual message processor are denied processing by the system. Operation of the system is monitored to determine a respective level of activity for each of the message processors and for the system. From the respective levels of activity a desired distribution of messages among the message processors and the virtual message processor is calculated. Messages are distributed from the distribution node to the message processors and the virtual message processor in accordance with the calculated desired distribution.

A system incorporating such a method is also provided.

Brief Description of the Drawings

The above and other objects and advantages of the invention will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

FIG. 1 is a schematic block diagram of a preferred embodiment of a system according to the present invention; and

FIG. 2 is a flow diagram showing the operation of a preferred embodiment of a system and method according to the present invention.

Detailed Description of the Invention

As stated above, the present invention can be used with any type of data processing system in which messages (i.e., data to be processed or communications to be routed) arrive at a distribution node and must be distributed among a plurality of processors, each of which remains responsible for any message sent to it until that message leaves the system. In the discussion that follows, the invention will be described in the context of a telephone switching system. However, such discussion is not intended to limit the present invention to such a system.

The system and method according to the present invention handles system overload by creating, preferably in software, an additional call processor in the system. That additional call processor is a "dummy" processor, in that it does not really exist and it processes no calls. Instead, it is used by the system as a mechanism to reject calls. Specifically, the system assigns calls arriving at a distribution node among the various call processors in accordance with their availability, which is determined by measuring system activity. When the measure of system activity indicates that a certain fraction of incoming calls should be rejected to prevent system degradation, the system assigns that fraction as the fraction of all calls to be handled by the "dummy" processor. When calls arrive at a distribution node, the distribution node assigns calls to the various call processors, including the "dummy" processor, in accordance with the fraction assigned to that processor. As far as the distribution node is concerned, the "dummy" processor is just another processor to be assigned calls. The distribution and allocation of calls and the control of system overload is integrated in the system and method of the invention, and thus operates efficiently.

The determination of the fractions of incoming calls to be assigned to each call processor, including the "dummy" processor, may be handled by a separate monitoring processor that monitors the condition of the various processors, as well as the fabric controller or controllers, to determine whether or not the system is overload and thus to determine a rejection percentage, and also to determine a level of activity for each processor to determine the fraction of accepted calls to assign to each processor. However, it is preferred that instead of a separate monitoring processor, the distribution node itself handle the monitoring function. Thus, in the preferred embodiment, the distribution node would query the various system components to determine their condition and level of activity at a regular interval Δt. At each interval Δt, then, the system would determine a rejection rate β for the system, as well as a set of fractions representing the allocations for the various call processors, to be used during that interval until the next measurement is taken. The allocations and rejection rate would thus be updated every Δt, so that they remain current.

In fact, the preferred embodiment of the system is likely to have a plurality of distribution nodes or SIPs. In such a

information about the trend. Any suitable technique may be used, such as exponential smoothing, as follows:

Each SIP 12 selects $0<\alpha<1$ and implements the following recursions:

$$\rho\ell^{C} = \alpha\rho\ell_{-1}{}^{C} + (1-\alpha)\rho\ell^{Cmeas} \tag{1}$$

and

$$\rho\ell^{B} = \alpha\rho\ell_{-1}{}^{B} + ((1-\alpha)/N)\sum_{i=1}^{N}\rho\ell^{Bi} \tag{2}$$

It is desirable to prevent FC 16 and CPs 14 from exceeding over long periods given target utilizations $\rho_{tar}{}^{C}$ and $\rho_{tar}{}^{B}$ respectively. To achieve this goal, the fraction of rejected calls during the ℓth period, called $\beta\ell$ is adjusted according to a recursion that can be expressed in terms of fraction of admitted calls:

$$1-\beta\ell=\min(1,(1-\beta\ell_{-1})\min((\rho_{tar}{}^{C}/\ell^{C}),(\rho_{tar}{}^{B}/\rho\ell^{B})) \tag{3}$$

Preferably, the fraction of accepted calls is increased whenever the (smoothed) utilizations of the FC 16 and the CPs 14 are below their targets, and is decreased at least one of them is above its target.

Each SIP 12 preferably acts autonomously. The system, however, is preferably initialized so that the measurements received by different SIPs 12 from the CPs 14 and the FC 16 are staggered. Hence, the call rejection measurement function preferably is activated about every T/M sec.

Call routing is determined as follows:

Each SIP 12 preferably keeps a set of N+1 variables $\{q_i\}$. The variable q_0 is associated with rejections, and each one of the other N variables relates to a specific CP 14. β_n refers to the fraction of job rejections at the time of the nth arrival epoch. Similarly, $\rho_n{}^{Bi}$ indicates the utilization of CP B_i at the nth arrival epoch.

The q-variables are initialized at zero, and updated at each arrival as follows:

$$a_n=\mathrm{argmax}\{q_i(n-1)\} \tag{4}$$

$$q_0(n)=q_0(n-1)+\beta_n,\ \text{for } a_n\neq 0 \tag{5a}$$

$$q_0(n)=q_0(n-1)+\beta_n-1,\ \text{for } a_n=0 \tag{5b}$$

$$q_i(n) = q_i(n-1) + (1-\beta_n)((1/\rho_n{}^{Bi})/\sum_{j=1}^{N}(1/\rho_n{}^{Bj})),\ \text{for } a_n\neq i>0 \tag{6a}$$

$$q_i(n) = q_i(n-1) + (1-\beta_n)((1/\rho_n{}^{Bi})/\sum_{j=1}^{N}(1/\rho_n{}^{Bj}))-1,\ \text{for } a_n=i> \tag{6b}$$

In an alternative embodiment, rejections are determined as shown above, but all call arrivals that are not rejected are distributed evenly among the CPs 14. When the rejection rate is zero, this collapses to a round-robin distribution. The distribution can be described mathematically as follows:

$$a_n=\mathrm{argmax}\{q_i(n-1)\}$$

$$q_0(n) = q_0(n-1) + \beta_n,\ \text{for } a_n \neq 0$$

$$q_0(n) = q_0(n-1) + \beta_n - 1,\ \text{for } a_n = 0$$

$$q_i(n) = q_i(n-1) + (1-\beta_n)/N,\ \text{for } a_n \neq i > 0$$

$$q_i(n) = q_i(n-1) + (1-\beta_n)/N - 1,\ \text{for } a_n = i > 0$$

3. The method of claim 2 wherein said monitoring and calculating steps are performed by said at least one distribution node.

4. The method of claim 3 wherein:

when said system comprises a plurality of said distribution nodes, said monitoring and calculating steps are performed independently by each of said distribution nodes; and
each of said distribution nodes distributes said messages to said message processors in accordance with a respective independently calculated desired distribution.

5. The method of claim 4 wherein said regular intervals are identical for all of said distribution nodes.

6. The method of claim 5 wherein said regular intervals occur at staggered times among said distribution nodes.

7. The method of claim 4 wherein said regular intervals are different for different ones of said distribution nodes.

8. The method of claim 2 further comprising establishing a respective credit bank corresponding to each said message processor and said virtual message processor; wherein:

said monitoring and calculating steps comprise:
whenever a message arrives at a distribution node, deriving from said desired distribution a respective fractional credit to be deposited in each respective credit bank, said respective fractional credits summing to one credit unit; and said distributing step comprises:
identifying one of said credit banks having a higher credit balance than any other one of said credit banks,
distributing said message to one of said message processors corresponding to said one of said banks having said higher credit balance, and
subtracting a unit of credit from said one of said banks having said higher credit balance.

9. The method of claim 1 wherein:

when said system comprises a plurality of said distribution nodes, said monitoring and calculating steps are performed independently by each of said distribution nodes; and
each of said distribution nodes distributes said messages to said message processors in accordance with a respective independently calculated desired distribution.

10. The method of claim 1 wherein, when said system comprises at least one system processor associated with said message processors, said monitoring step comprises monitoring activity of said at least one system processor as part of said level of activity for said system.

11. The method of claim 1 wherein said calculating step comprises calculating a desired distribution in which a fraction of arriving messages is directed to said virtual message processor, and all messages not directed to said virtual message processor are distributed uniformly among said message processors.

12. The method of claim 1 wherein said calculating step comprises calculating a desired distribution in which a fraction of arriving messages is directed to said virtual message processor, and all messages not directed to said virtual message processor are distributed among said message processors according to said levels of activity of said message processors.

13. The method of claim 12 wherein:

said monitoring step comprises determining said levels of activity as a function of number of messages being serviced by each of said message processors; and
said calculating step comprises calculating a desired distribution in which a fraction of arriving messages is directed to said virtual message processor, and all messages not directed to said virtual message processor are distributed among said message processors in inverse proportion to said numbers of messages being serviced by each of said message processors.

14. The method of claim 12 wherein:

each of said distribution nodes operates independently as said monitor and said distribution calculator; and
each of said distribution nodes distributes said messages to said message processors in accordance with a respective independently calculated desired distribution.

24. The system of claim 15 further comprising at least one system processor associated with said message processors; wherein:

said monitor monitors activity of said at least one system processor as part of said level of activity for said system.

25. The system of claim 15 wherein said distribution calculator calculates a desired distribution in which a fraction of arriving messages is directed to said virtual message processor, and all messages not directed to said virtual message processor are distributed uniformly among said message processors.

26. The system of claim 15 wherein said distribution calculator calculates a desired distribution in which a fraction of arriving messages is directed to said virtual message processor, and all messages not directed to said virtual message processor are distributed among said message processors according to said levels of activity of said message processors.

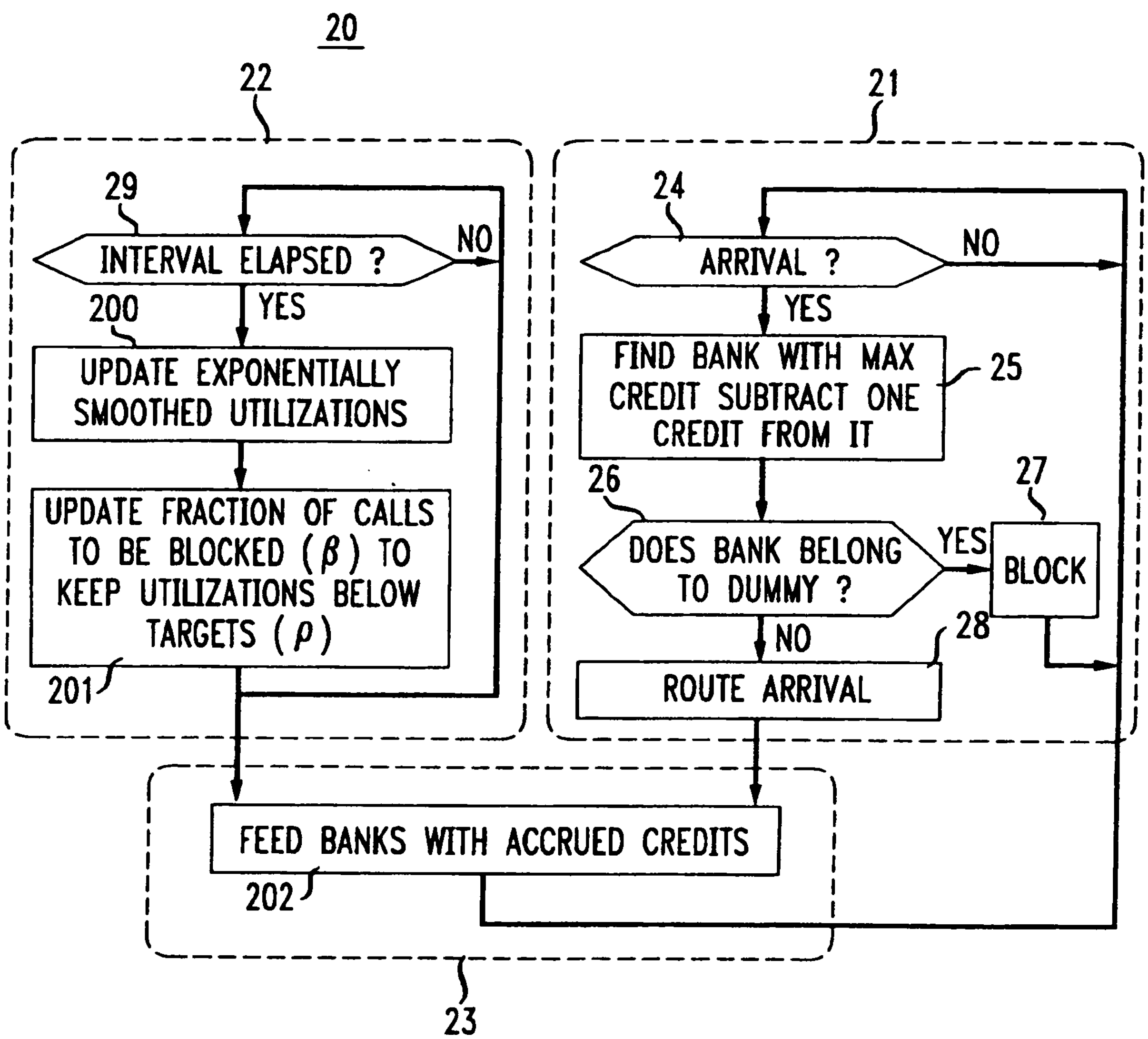
27. The system of claim 26 wherein:

said monitor determines said levels of activity as a function of number of messages being serviced by each of said message processors; and
said distribution calculator calculates a desired distribution in which a fraction of arriving messages is directed to said virtual message processor, and all messages not directed to said virtual message processor are distributed among said message processors in inverse proportion to said numbers of messages being serviced by each of said message processors.

28. The system of claim 26 wherein:

said monitor determines said levels of activity as a function of utilization of each of said message processors; and
said distribution calculator calculates a desired distribution in which a fraction of arriving messages is directed to said virtual message processor, and all messages not directed to said virtual message processor are distributed among said message processors in inverse proportion to said utilization of each of said message processors.

FIG. 2


20
22
21
29
INTERVAL ELAPSED ?
NO
YES
200
UPDATE EXPONENTIALLY SMOOTHED UTILIZATIONS
UPDATE FRACTION OF CALLS TO BE BLOCKED (β) TO KEEP UTILIZATIONS BELOW TARGETS (ρ)
201
24
ARRIVAL ?
NO
YES
FIND BANK WITH MAX CREDIT SUBTRACT ONE CREDIT FROM IT
25
26
27
DOES BANK BELONG TO DUMMY ?
YES
BLOCK
NO
28
ROUTE ARRIVAL
FEED BANKS WITH ACCRUED CREDITS
202
23

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(74) Representative: Kuhnen & Wacker
Patentanwaltsgesellschaft mbH,
Alois-Steinecker-Strasse 22
85354 Freising (DE)

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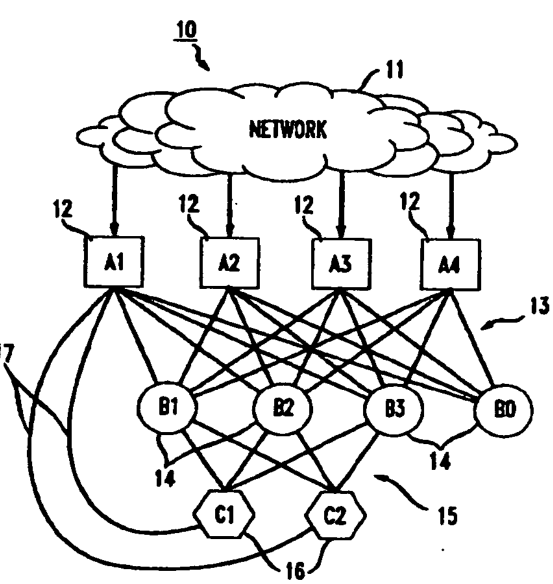

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 97 11 5569

24-02-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4974256 A	27-11-1990	NONE	